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Control of Tomato Diseases by Spraying

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A Severe Attack of Early Blight on Nonsprayed Tomatoes.

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ABSTRACT

A NUMBER of fungicides and several combinations of Fermate or Zerlate with various copper fungicides were used in tests during 1944 to 1946, inclusive, to determine which fungicide or combination of fungicides would give the most effective control, with the least amount of plant injury, of the following diseases of tomatoes in western New York: Early blight, *Alternaria solani* (E. & M.) J. & G.; anthracnose, *Colletotrichum phomoides* (Sacc.) Chester; late blight, *Phytophthora infestans* (Mont.) DeBary; and leaf mold, *Cladosporium fulvum* Cooke.

No single fungicide, adequately tested, gave maximal control of all four diseases. The fixed coppers gave good control of leaf mold, early blight, and late blight but were slightly inferior to bordeaux 8–4–100 for the control of early and late blights. No copper fungicide tested gave adequate control of anthracnose and all were injurious, some more than others, when used in the early applications. Phygon gave good control of early blight, late blight, and anthracnose but caused a fruit discoloration. Dithane D–14 and He 178e gave good control of early and late blight but were not adequately tested against anthracnose or leaf mold. Zerlate was more effective than Fermate because of equal control of anthracnose and better control of early blight and leaf mold; neither was very effective against late blight.

The best control of the four diseases was obtained with alternate schedules of Fermate or Zerlate and various copper fungicides, the Zerlate-bordeaux schedule in the following order of applications being outstanding: Zerlate-Zerlate-bordeaux-Zerlate-bordeaux, using an 8–4–100 bordeaux and Zerlate at 2 pounds to 100 gallons. No apparent injury resulted from this schedule, due probably to the fact that the bordeaux was not applied until after August 1 after which time defloration, the principal injury factor, is not reflected in yield except during an unusually prolonged harvest season.

Bulletin No. 724

CONTROL OF TOMATO DISEASES BY SPRAYING

W. T. SCHROEDER

INTRODUCTION

The yield and quality of field-grown tomatoes in New York, especially those for processing, are often seriously reduced by a number of fruit and foliage diseases. In the past, control of at least five of these has been known to be influenced to some degree by the application of various fungicides.

Early blight, *Alternaria solani* (E. & M.) J. & G., and anthracnose, *Colletotrichum phomoides* (Sacc.) Chester, occur more commonly and over a period of years account for the major portion of the damage. In recent years, however, late blight, *Phytophthora infestans* (Mont.) DeBary, has developed extensively in some areas in western New York, and in 1946 reached epiphytotic proportions with the destruction of a considerable acreage. The other two diseases, Septoria blight, *Septoria lycopersici* Speg., and leaf mold, *Cladosporium fulvum* Cooke, are of secondary importance but may cause serious losses in areas where poor rotations or unsanitary conditions prevail, either in the field or plant beds.

The experiments reported herein were carried out during 1944 to 1946, inclusive, in a number of representative tomato-growing counties in western New York. The primary purpose was to determine which fungicide or combination of fungicides would give the most satisfactory control, with the least amount of plant injury, of the major diseases, early blight, anthracnose, and late blight. An evaluation of the various treatments against the other two diseases, leaf mold and Septoria blight, was desirable. The practicability of spraying tomatoes is not given major emphasis since it is not necessarily dependent on cost of spraying and yield alone, and must be determined by individual growers and processors. This is especially true in New York where tomatoes are grown in areas differing with respect to climatic conditions, rotations, and methods of marketing the harvested crop.

Prior to 1942, the only fungicides that showed any promise against the aforementioned diseases were the various copper compounds. Altho

giving good control of the various leaf blights, these compounds were not very effective against anthracnose. Furthermore, all produced plant injury, some more than others, so that spraying became profitable only when the damage from disease was greater than that from the phytotoxic properties of the fungicide (1, 3, 7, 8).[1]

In 1941 and 1942, Wilson (9) and McNew (5) demonstrated that Fermate, a new organic fungicide (ferric dimethyl dithiocarbamate), was more effective against anthracnose than any of the copper compounds. This material, however, was not as good as the coppers against early and Septoria blights. The use of the alternating schedules of Fermate and the various copper materials in the experiments reported herein has as its basis the suggestion by McNew (5) that Fermate and the coppers, in a dual program, might give satisfactory control of both anthracnose and early blight. Zerlate (zinc dimethyl dithiocarbamate), a compound similar to Fermate, was given preliminary trial in 1944 and included in the alternate schedules in a subsequent experiment for comparison with Fermate.

MATERIALS AND METHODS

The various materials used as fungicides in these investigations were furnished by the manufacturers and are listed in Table 1. Bordeaux 8–4–100 was the only formulation of this fungicide used. The concentrations used and number of applications by dates are given in the separate tables.

The term "alternate schedule," as used in this paper, indicates one in which two different materials are applied at normal concentrations on different dates of a five-application schedule.

The location of the experiments, the plot size, and the type of boom used to apply the sprays varied with the individual experiments. A number of the tests were scattered in various tomato-growing counties in western New York, on fields selected because of grower cooperation prompted by a desire to determine for himself the practicability of spraying. Others were carried out on the Station farms at Geneva.

The size of the plots in the tests at Auburn, Albion, Fredonia, and Pittsford was approximately ½ acre, and each treatment was placed in random order in each of three blocks. Sprays were applied to these plots with either tractor-mounted or trailer-drawn potato spray rigs similar to the one shown in Fig. 1. In all other experiments, 10- to 30-plant plots were used. These smaller plots were placed in random order in each of four to six blocks, depending upon the individual experiment. Except for 1944, the rows of the smaller plots were 6 feet apart and the plants within the row 2½ feet apart. Nonsprayed buffer rows were situated between each of the small plots in the 1946 experiments.

[1]Figures in parenthesis refer to Literature Cited, page 28.

TABLE 1.—A LIST OF THE MATERIALS USED IN THE EXPERIMENTS, TOGETHER WITH THEIR COMPOSITION AND MANUFACTURER.*

MATERIAL	COMPOSITION	MANUFACTURER
COCS (44%)	Copper oxychloride sulfate (44% Cu)	Harshaw Chemical Co.
COCS (53%)	Copper oxychloride sulfate (53% Cu)	Harshaw Chemical Co.
Copper Hydrate No. 3	Copper hydroxide (63% Cu)	Harshaw Chemical Co.
Tenn. Tribasic	Tribasic copper sulfate (53% Cu)	Tennessee Copper Co.
Microgel	Tribasic copper sulfate (53% Cu)	Tennessee Copper Co.
Phelps-Dodge Tribasic	Tribasic copper sulfate (54% Cu)	Phelps Dodge Refining Corp.
Copper Compound A	Copper oxychloride (45% Cu)	E. I. DuPont de Nemours Co.
Fermate	Ferric dimethyl dithiocarbamate (70%)	E. I. DuPont de Nemours Co.
Zerlate	Zinc dimethyl dithiocarbamate (70%)	E. I. DuPont de Nemours Co.
Methasan	Zinc dimethyl dithiocarbamate	Monsanto Chem. Co.
Dithane B-11	Disodium ethylene bisdithiocarbamate (zinc reaction powder)	Rohm and Haas Co.
Dithane A-10	Disodium ethylene bisdithiocarbamate (powder)	Rohm and Haas Co.
Dithane D-14	Disodium ethylene bisdithiocarbamate hexahydrate (25%)	Rohm and Haas Co.
He 178e	Zinc ethylene bisdithiocarbamate	Rohm and Haas Co.
U. S. R. No. 604	2,3-dichloro-1, 4-naphthoquinone	U. S. Rubber Co.
Phygon	2,3-dichloro-1, 4-naphthoquinone (87%)	U. S. Rubber Co.
Q-15	Lauryl isoquinolinium bromide (20%)	Onyx Oil & Chem. Co.
Omilite	Polyethylene polysulfide (40%)	B. F. Goodrich Chemical Co.

*The writer is grateful to the manufacturers listed here for supplying the materials; to the following County Agricultural Agents for their cooperation in conducting the experiments: L. E. Curtis (Wayne), C. V. Flagg (Chautauqua), C. F. Handy (Monroe), C. L. Messer, Jr. (Cayuga), and A. G. West (Orleans); and to the following growers for their interest and cooperation: Carl and Herman Dickman, Auburn, N. Y., Russell Joy, Fredonia, N. Y., Ora Lee, Albion, N. Y., Harold Pugsley, Lincoln, N. Y., and Norman van Voorhis, Pittsford, N. Y. Acknowledgment is also made to Dr. G. E. R. Hervey of this Station for the photographs used in this bulletin.

These plots were sprayed with a hand-carried boom. In both the large and small plots the nozzle arrangement on the booms was such as to provide one nozzle for each foot of row width, 6-foot rows, therefore, being sprayed with six nozzles per row. Each nozzle was fixed to a flexible joint so that the spray could be directed into the plants when small and later adjusted to a brush-type boom when the weight of the fruit flattened the vines. In the first three applications, extension arms were placed on the first and last nozzle of each row to enable the spray cone to reach the crown and underside of the leaves.

Unless otherwise noted, all sprays were applied at the rate of approximately 200 gallons per acre thru No. 3 discs at a pressure of 400 pounds, except in the 1944 experiments when 300 pounds pressure was used.

The percentages of foliage infection and defoliation were usually recorded at the time of the peak harvest of the nonsprayed plots. Such

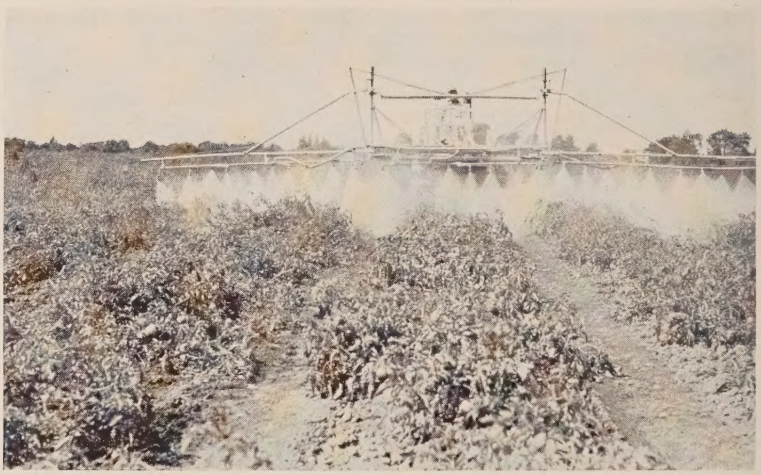

FIG. 1.—TYPE OF SPRAY RIG USED TO APPLY FUNGICIDES TO LARGE TOMATO PLOTS.

Brush-type arrangement of boom used late in the season when vines are prostrate.

data are based on the average estimates of all plants within the small plots and on blocks of plants within the large plots. Fruit infection data were obtained by grading each fruit harvested from the small plots and by examining the fruit in a number of hampers selected at random from the large plots. U. S. Standard grades were similarly obtained. The yields of graded fruit are expressed as No. 1 equivalents, obtained by converting the weight of the No. 2 fruit to No. 1 equivalents, based on the relative prices for the two grades, and adding this to the weight of the fruit originally graded as No. 1.[2] Such fruit has the value of that for No. 1, which during the years of these investigations was approximately $30.00 per ton.

RESULTS

1944 EXPERIMENTS

A comparison of a number of materials was made in duplicate experiments at Geneva and Lincoln, N. Y. Data were taken on the two center rows of each four-row plot containing 15 plants per row (Table

[2]For example, assume that No. 1 fruit sold for $30 a ton and No. 2 fruit for $19 a ton. Assume further that the yield of No. 1 fruit was 6 tons to the acre and of No. 2 fruit 4 tons to the acre. To convert the total yield to No. 1 equivalents, the following formula is applied: 4 tons of No. 2 fruit $\times$ 19/30 + 6 tons of No. 1 fruit = No. 1 equivalents in tons per acre.

TABLE 2.—EFFECT OF EIGHT DIFFERENT SPRAY MATERIALS ON EARLY BLIGHT DEFOLIATION OF JOHN BAER TOMATOES AT GENEVA AND LINCOLN, 1944.

MATERIAL*	CONCENTION, LBS. PER 100 GALS.	DEFOLIATION, PER CENT		YIELD, TONS PER ACRE†	
		Geneva	Lincoln	Geneva	Lincoln
None	—	83	97	13.4	20.7
Bordeaux	8.00+4.00	31	49	13.3	27.1
Microgel	4.00	50	48	13.2	21.7
COCS (44%)	4.55	51	58	13.5	24.1
U. S. R. No. 604	1.50	69	71	14.4	21.2
Dithane (B-11)	3.00	65	74	12.9	22.1
Fermate	2.00	62	83	12.7	23.2
Fermate+Microgel	1.00+2.00	57	64	12.9	22.5
Fermate – Microgel	2.00 – 4.00	53	60	13.2	23.6
Least difference required for significance (19:1)		6	8	NS‡	3.8

*Dates of application: At Geneva, July 14 and 26, Aug. 7 and 21; At Lincoln, July 10 and 24, Aug. 3 and 24. Fermate-Microgel schedule, alternate applications, beginning with Fermate and ending with Microgel. Fermate + Microgel = mixture of the two fungicides at one-half normal concentration of each.

†Dates of harvest: At Geneva, Aug. 23, Sept. 7, 13, and 22; At Lincoln, Aug. 23, Sept. 5 and 15.

‡NS = Not statistically significant by analysis of variance.

2). Early blight was the only measurable disease that developed at either location. Bordeaux, the most effective material at Geneva, was matched only by Microgel at Lincoln. Microgel, COCS, and the alternate schedule of Fermate-Microgel gave equal control at Geneva, but Microgel was superior to the latter two at Lincoln. Fermate was superior to U. S. R. No. 604 at Geneva, but inferior to it and to Dithane B–11 at Lincoln. None of the organic fungicides alone gave as good control of early blight defoliation as the coppers or the alternate schedule of Fermate-Microgel at either location. The yield data from these two locations are given as ungraded fruit, since it was impossible to obtain grades. None of the treatments at Geneva was significantly different from the nontreated plots. At Lincoln, only the bordeaux-sprayed plots yielded significantly higher than the nonsprayed, which were lowest in yield. The only qualitative phytotoxicity apparent in this experiment occurred on the fruit of plants sprayed with U. S. R. No. 604. This injury, characterized by a superficial blackening, occurring in blotches on the skin of the ripe fruit, is not apparent beneath the epidermis; nevertheless, it presents an unsightly appearance, especially on market fruit (Fig. 2).

Two diseases, early blight and anthracnose, developed in another experiment on a different farm at Geneva, wherein two copper and

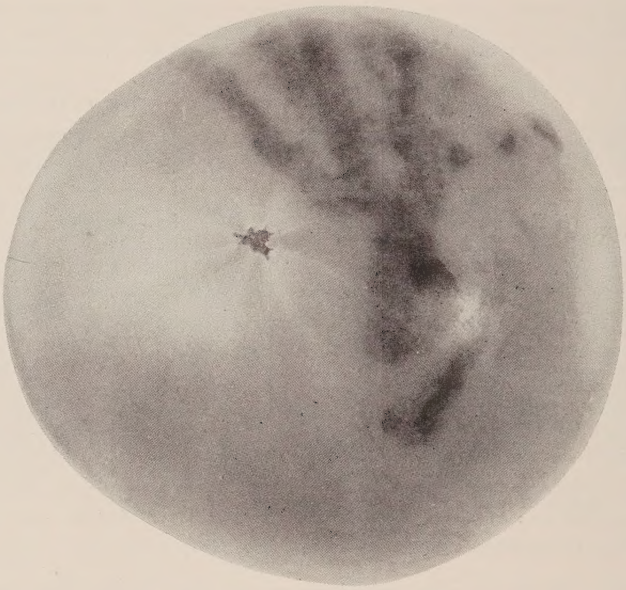

FIG. 2.—PHYGON INJURY ON FRUIT.
Black discoloration is restricted to epidermis.

three organic fungicides were being compared (Table 3). Early blight defoliation was significantly less in the bordeaux plots than in those sprayed with COCS. The organic fungicides were least effective. Of these, Fermate and U. S. R. No. 604 resulted in less defoliation than Dithane A–10. Fermate and U. S. R. No. 604 controlled anthracnose better than any of the other fungicides. All except bordeaux were significantly better than no spray, altho Dithane A–10 was only slightly better than bordeaux. The latter material, which was superior to COCS for early blight control, was inferior to it for anthracnose control. Altho the yields of ungraded fruit from the sprayed plots were no lower than that of the control, none of them was significantly higher.

The relative effectiveness of Fermate, Tennessee Tribasic, and an alternate schedule of Fermate-Tennessee Tribasic against anthracnose and early blight was determined in an experiment at Geneva. Artificial inoculum of the anthracnose organism in the form of infested wheat kernels was applied to the base of each plant prior to the first spray application. A natural infection of early blight developed and accounted for considerable defoliation in these plots (Table 4). The control of

TABLE 3.—EFFECT OF FIVE FUNGICIDES ON EARLY BLIGHT DEFOLIATION, ANTHRACNOSE, AND YIELD OF THE JOHN BAER TOMATO, GENEVA, 1944.

FUNGICIDE*	CONCENTRATION, LBS. PER 100 GALS.	DEFOLIATION, PER CENT	ANTHRACNOSE, PER CENT	YIELD, TONS PER ACRE
None	—	79	4.5	8.6
Bordeaux	8.00+4.00	42	3.7	9.3
COCS (44%)	4.55	48	2.3	8.6
Fermate	2.00	55	1.2	9.6
U. S. R. No. 604	1.50	60	0.7	9.0
Dithane (A-10)	1.50	68	3.1	10.0
Least difference required for significance (19:1)		6	1.0	NS

*Dates of application: July 18 and 27; Aug. 8 and 22.
†Dates of harvest: Aug. 30; Sept. 11, 20, and 27.

these two diseases obtained with the alternate schedule was not exceeded by either Tennessee Tribasic or Fermate, altho equalled by Tennessee Tribasic for early blight defoliation and by Fermate for anthracnose. All were better than no spray. Higher yields of No. 1 equivalent fruit were obtained from all treatments, but the differences were not significant.

Summary of 1944 results.—The performances in 1944 of the various fungicides against two of the diseases indicate a number of trends. The bordeaux mixture used was never exceeded by, and more often was superior to, the other fungicides, including the fixed coppers, for the control of early blight. Contrarily, it appeared to be the least ef-

TABLE 4.—EFFECT OF THREE FUNGICIDE TREATMENTS ON EARLY BLIGHT DEFOLIATION, ANTHRACNOSE, AND YIELD OF THE JOHN BAER TOMATO, GENEVA, 1944.

TREATMENT*	CONCENTRATION, LBS. PER 100 GALS.	DEFOLIATION, PER CENT	ANTHRACNOSE, PER CENT	YIELD, TONS PER ACRE OF NO. 1 EQUIV.†
None	—	87	18.7	9.0
Fermate	2.0	36	3.7	10.8
Tenn. Tribasic	4.0	27	8.3	11.3
Fermate-Tenn. Tribasic	2.0–4.0	27	3.3	11.8
Least difference required for significance (19:1)		5	3.4	NS

*Dates of application: July 15 and 29; Aug. 8 and 21; Sept. 1. Alternate schedule started with Fermate and ended with Fermate.
†Dates of harvest: Aug. 16 and 26; Sept. 9, 16, 23, and 28.

fective against anthracnose, even less so than the fixed coppers. Fermate and U. S. R. No. 604 gave the best control of anthracnose, but the latter material produced an objectionable fruit discoloration. No single fungicide performed most effectively against both diseases. The alternate schedule of Fermate-Microgel appeared to be more promising against early blight and anthracnose than any one of the specific fungicides alone. The yield differences obtained in these experiments were not conclusive.

1945 EXPERIMENTS

In view of the fact that none of the individual fungicides tested in 1944 gave maximal control of both early blight and anthracnose, it was deemed advisable to continue testing various available fungicides in 1945 in anticipation of finding one that would be effective against two or more of the three major tomato diseases. The promising performance in 1944 of the alternate schedule of Fermate-Microgel prompted a number of experiments in different areas to compare the effectiveness of Fermate and various copper compounds, either alone or in alternate schedules, against early blight, anthracnose, or any of the other diseases that might develop. Zerlate, a promising fungicide against anthracnose, was included also.

TABLE 5.—EFFECT OF VARIOUS ORGANIC AND INORGANIC FUNGICIDES ON EARLY BLIGHT, DEFOLIATION, AND YIELD OF THE JOHN BAER TOMATO, GENEVA, 1945.

FUNGICIDE*	CONCENTRATION, LBS. PER 100 GALS.	EARLY BLIGHT, PER CENT	DEFOLIATION, PER CENT	YIELD, TONS PER ACRE No. 1 EQUIV.†
None	—	82	78	9.9
Bordeaux	8.0+4.0	11	47	9.8
COCS (44%)	4.55	14	62	9.4
Microgel	4.00	13	58	11.3
Tenn. Tribasic	4.00	13	59	9.7
Copper Compound A	4.00	13	57	9.8
Phelps-Dodge Tribasic	4.00	13	52	10.0
Fermate-Tenn. Tribasic	2.0–4.0	13	47	10.8
Fermate	2.00	21	44	11.1
Zerlate	2.00	15	34	12.0
Methasan	2.00	15	42	11.2
U.S.R. No. 604	2.00	13	42	10.4
Dithane (D-14)-$ZnSO_4$-lime	2 qts.–1.0–0.5	15	35	11.1
Least difference required for significance (19:1)		11	22	1.9

*Dates of application: July 13 and 23; Aug. 3, 17, and 29. Alternate schedule of Fermate-Tenn. Tribasic started and ended with Fermate.

†Dates of harvest: Aug. 15 and 21; Sept. 4 and 20.

Eleven different fungicides, six coppers and five organics, were tested along with an alternate schedule of Fermate-Microgel at Geneva (Table 5). Early blight, the only recognized disease present, developed to a mild extent, and the percentages of leaves showing infection were recorded. No significant differences with respect to control of this disease occurred among the various fungicides, altho Fermate was slightly inferior, which confirmed the previous year's data. All fungicides, however, were better than no spray treatment. A disease or soil condition, the causal factor of which was not determined, accounted for the most of the defoliation in this field and a differential response to the various treatments occurred. Excluding the nonsprayed plots, the defoliation was highest among the fixed coppers and lowest among the organics, Zerlate and Dithane D–14 being outstanding. Bordeaux and the alternate schedule were intermediate. Only Zerlate resulted in a significant increase in yield, altho Microgel, Methasan, Fermate, Dithane D–14, and the alternate schedule followed in close order. The fruit from plants sprayed with U. S. R. No. 604 again showed the discoloration previously described.

The better control of the unknown defoliation by the organics set forth in Table 5 was further demonstrated in a factorial experiment set up in the same field to compare varying numbers of applications of Tennessee Tribasic with Zerlate (Table 6). Early blight was present in these plots, but only a minor portion of the defoliation was attributed to it. Zerlate was more effective than Tennessee Tribasic against this type of defoliation, regardless of the number of applications. Tennessee Tribasic did not reduce the defoliation with one application, but Zerlate did. In general, defoliation was reduced with increasing numbers of applications, altho the differences between three and five applications of Tennessee Tribasic and four and five applications of Zerlate were not significant. Increases in yield of No. 1 equivalent fruit were proportional to the number of applications up to four and five which were not significantly different. With Tennessee Tribasic only the plots sprayed four times yielded significantly higher than no spray; whereas, those sprayed either three, four, or five times with Zerlate yielded higher.

The effectiveness against leaf mold of several coppers, Fermate, and Zerlate, either alone or in various alternations was determined in two experiments at Geneva. In one experiment involving COCS and Fermate in straight schedules and the alternate schedules outlined in Table 7, leaf mold accounted for practically all of the defoliation. In all the

TABLE 6.—INFLUENCE OF TWO FUNGICIDES AND NUMBER OF APPLICATIONS ON DEFOLIATION AND YIELD OF THE JOHN BAER TOMATO, GENEVA, 1945.

NUMBER OF APPLICATIONS*	YIELD, TONS PER ACRE OF NO. 1 EQUIV.†			DEFOLIATION, PER CENT		
	Tenn. Tribasic	Zerlate	Av.	Tenn. Tribasic	Zerlate	Av.
0	10.3	10.3	10.3	75	75	75
1	11.4	10.3	10.8	74	62	68
2	10.9	11.4	11.2	50	41	45
3	11.2	12.6	11.9	33	27	30
4	12.5	14.4	13.5	30	19	24
5	11.5	13.9	12.7	28	16	22
Fungicide average	11.5	12.5		43	33	

Least difference for significance between individual treatments (19:1), 1.9 tons; 10 per cent.
Least difference for significance between fungicide averages (99:1), 1.0 ton; 5 per cent.
Least difference for significance between application averages (19:1), 1.2 tons; 6 per cent.

*Dates of applications: July 17 and 24; Aug. 4, 17, and 29. Tennessee Tribasic used at 4 pounds per 100 gallons; Zerlate at 2 pounds per 100 gallons.
†Dates of harvest: Aug. 20; Sept. 6 and 24; Oct. 5.

spray schedules in this experiment defoliation was reduced from 84 per cent to from 23 to 28 per cent. Straight applications of COCS were just as effective as Fermate. Among the alternate schedules, however, some were slightly superior to the others. It is interesting to note that with virtually the same disease control plots sprayed with two of the schedules yielded less than those not sprayed, altho not significantly so. In both of these schedules two or more copper sprays were made in the first three applications, suggesting the possibility of greater injury with the early applications of copper. Only the alternate schedule of Zerlate-bordeaux produced a significantly higher yield than the control.

Leaf mold developed in another experiment at Geneva, wherein Fermate and Zerlate were compared with an alternate schedule of Fermate-Microgel. Early blight and anthracnose also developed and were recorded, the leaf mold and early blight being expressed as percentages of leaves showing infection (Table 8). Unlike the preceding experiment, Fermate was inferior to the alternate schedule for the control of leaf mold. Zerlate was most effective, and all were better than no spray (Fig. 3). Altho better than the control, Fermate was inferior to Zerlate and the alternate schedule against early blight. No

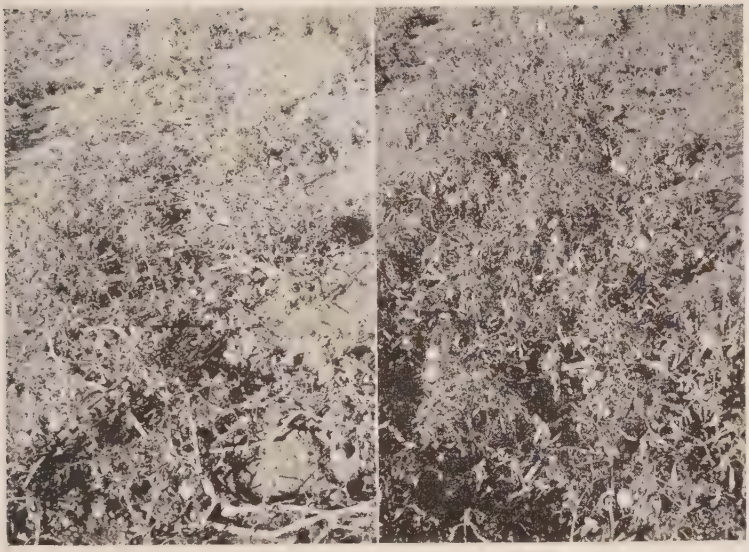

FIG. 3.—CONTROL OF LEAF MOLD.
Plot at left not sprayed; plot at right sprayed five times with Zerlate.

significant differences in anthracnose control occurred among any of the three treatments, and all were superior to no spray. Fermate and the alternate schedule resulted in yields significantly higher than those

TABLE 7.—EFFECT OF DIFFERENT ALTERNATE SPRAY SCHEDULES ON CLADOSPORIUM LEAF MOLD AND YIELD OF THE JOHN BAER TOMATO, GENEVA, 1945

SPRAY SCHEDULE*	LEAF MOLD DEFOLIATION, PER CENT	YIELD, TONS PER ACRE NO. 1 EQUIV.†
O-O-O-O-O	84	13.3
C–C–C–C–C	27	13.0
F–C–F–C–F	27	14.1
F–C–C–F–C	28	13.2
F–F–F–F–F	26	14.8
F–C–F–C–C	28	14.2
F–F–B–F–B	23	14.2
Z–Z–B–Z–B	24	15.0
Least difference required for significance (19:1)	5	1.6

*Dates of application: July 14 and 24; Aug. 7 and 18; Sept. 12. C = COCS (44%) at 4.55 pounds per 100 gallons; F = Fermate at 2.0 pounds per 100 gallons; Z = Zerlate at 2.0 pounds per 100 gallons; B = Bordeaux 8–4–100; O = No spray.
†Dates of harvest: Aug. 20 and 31; Sept. 13; and Oct. 3.

TABLE 8.—EFFECT OF THREE FUNGICIDE TREATMENTS ON THE DEVELOPMENT OF EARLY BLIGHT, LEAF MOLD, AND ANTHRACNOSE AND ON THE YIELD OF THE JOHN BAER TOMATO, GENEVA, 1945.

TREATMENT*	CONCENTRATION, LBS. PER 100 GALS.	LEAF INFECTION, PER CENT		ANTHRACNOSE, PER CENT	YIELD, TONS PER ACRE No. 1 EQUIV.†
		Early blight	Leaf mold		
None	—	93	89	12.9	11.3
Fermate	2.0	63	43	3.6	13.9
Fermate-Microgel	2.0–4.0	31	23	2.6	13.7
Zerlate	2.0	36	17	2.5	12.9
Least difference required for significance (19:1)		6	15	3.2	2.2

*Dates of application: July 14 and 24; Aug. 3 and 17; Sept. 12. Alternate schedule of Fermate-Microgel started and ended with Fermate.
†Dates of harvest: Aug. 20 and 31; Sept. 13 and 28.

in the control plots. The slightly lower yield with Zerlate can be attributed in part to the poor condition of one plot which justifiably could not be removed from the statistical analysis.

Leaf mold, early blight, anthracnose, and a small amount of late blight developed in a large-plot experiment at Albion, N. Y., designed to compare a straight Tennessee Tribasic schedule with three different alternate schedules (Table 9). Tennessee Tribasic was just as effective in the control of leaf mold as any of the alternate schedules, all of which were definitely better than no spray. Defoliation, attributed to

TABLE 9.—INFLUENCE OF DIFFERENT SPRAY SCHEDULES ON THE CONTROL OF LEAF MOLD, EARLY BLIGHT, LATE BLIGHT, AND ANTHRACNOSE AND ON THE YIELD OF THE COBURG TOMATO, ALBION, 1945.

SCHEDULES*	LEAF MOLD, PER CENT	DEFOLIATION, PER CENT†	ANTHRACNOSE, PER CENT	YIELD, TONS PER ACRE No. 1 EQUIV.‡
O–O–O–O–O	84	61	18.6	8.2
T–T–T–T–T	21	26	14.1	8.9
F–T–F–T–F	24	36	8.6	9.4
Z–Z–B–Z–B	18	28	5.2	10.5
F–F–B–F–B	21	31	5.2	10.6
Least difference required for significance (19:1)	13	9	7.4	0.8

*Dates of application: July 16 and 25; Aug. 1, 11, and 29. O = No spray; T = Tennessee Tribasic at 4 pounds per 100 gallons; F = Fermate at 2 pounds per 100 gallons; Z = Zerlate at 2 pounds per 100 gallons; B = Bordeaux 8–4–100.
†Defoliation resulting principally from early blight; leaf mold also contributed.

both leaf mold and early blight, was significantly less in all spray treatments, Tennessee Tribasic being superior to the alternate schedule of Fermate-Tennessee Tribasic, but not to the Fermate-bordeaux or Zerlate-bordeaux alternate schedules. Altho late blight was present, none was observed on the harvested fruit except in the unsprayed plots, which showed 3 per cent infection, indicating almost perfect control under the prevailing conditions of this test. Leaf mold and early blight developed to a considerable extent and undoubtedly affected the yield somewhat; nevertheless, anthracnose was the most important disease. The control of this disease obtained with the Fermate-bordeaux or Zerlate-bordeaux schedules was slightly better than that obtained with the Fermate-Tennessee Tribasic alternate schedule, due possibly to the different arrangement of the fungicides. All three were significantly better than no spray, but the differences between the Fermate-Tennessee Tribasic schedule and straight Tennessee Tribasic or the latter and no spray were not significant. The yield of No. 1 equivalent fruit followed in the same order as the anthracnose control, the alternate schedules of Fermate-bordeaux and Zerlate-bordeaux resulting in a significantly higher yield than any other treatment.

An experiment similar to that at Albion was carried out in a commercial field at Auburn, N. Y., but differed in that COCS was used instead of Tennessee Tribasic and the alternate schedules of Fermate-COCS

TABLE 10.—THE INFLUENCE OF DIFFERENT SPRAY SCHEDULES ON THE CONTROL OF EARLY BLIGHT AND ANTHRACNOSE AND ON THE YIELD OF THE JOHN BAER TOMATO, AUBURN, 1945.

SCHEDULES*	EARLY BLIGHT		ANTHRACNOSE, PER CENT	YIELD, TONS PER ACRE NO. 1 EQUIV.†
	Defoliation, per cent	Fruit rot, per cent		
O–O–O–O–O	70	11.7	3.5	8.9
C–C–C–C–C	20	2.7	1.5	9.8
C–F–F–C–F	23	5.2	0.8	10.1
C–F–C–F–C	14	3.5	0.6	10.5
F–F–B–F–B	21	1.8	0.2	11.3
Least difference required for significance (19:1)	9	1.6	0.6	NS

‡Dates of harvest: Sept. 10 and 20; Oct. 5.
Dates of application: July 18 and 28; Aug. 9, 20, and 31. O = No spray; C = COCS (44%) at 4.55 pounds per 100 gallons; F = Fermate at 2.0 pounds per 100 gallons; B = Bordeaux 8–4–100.
†Dates of harvest: Sept. 12 and 26.

were arranged differently. The alternate schedule of Fermate-bordeaux was identical to that at Albion. Anthracnose was present but did not develop as extensively as at Albion (Table 10). The control, however, was comparable in that the Fermate-bordeaux schedule was slightly better than either of the two Fermate-COCS schedules, which in turn were better than the straight COCS schedules or no spray. COCS was significantly better than no spray, which was not the situation at Albion with Tennessee Tribasic. Early blight was the predominant disease and accounted for most of the destruction. Data were secured on defoliation and fruit rot phases of this disease. The schedule involving three applications of COCS and two of Fermate resulted in better control of early blight defoliation than that with two applications of COCS and three of Fermate, but was not significantly better than the Fermate-bordeaux which had only two applications of copper. The straight COCS applications produced no better control than any of the alternate schedules. The fruit rot resulting from early blight was significantly lower in the plots sprayed with the Fermate-bordeaux schedule than in those sprayed with either of the two Fermate-COCS schedules, but no lower than that in the straight COCS plots. Of the two Fermate-COCS schedules, the one with three applications of COCS was significantly lower in percentage of fruit rot than that with only two applications of COCS. The nonsprayed plots were decidedly inferior to those sprayed. The yields of No. 1 equivalent fruit, altho not significantly different, are proportional to the control of early blight and anthracnose in that the Fermate-Bordeaux schedule was slightly better than the two Fermate-COCS schedules which were better than the straight COCS schedule. It is interesting to note that altho the straight COCS schedule gave practically as good control of early blight as the Fermate-bordeaux schedule, it yielded 1.5 tons less fruit per acre. The difference in amount of anthracnose could not account for this, but rather greater phytotoxicity with the five straight applications of copper is suggested. The differences in yield between the sprayed and nonsprayed plots would have been much greater had it not been for a heavy frost that occurred about 5 days prior to the anticipated third harvest. An estimation by the grower of 4 to 6 tons per acre harvest on the sprayed plots would have been made at this time, compared with a ½ ton harvest on the nonsprayed plots. The condition of the vines in the sprayed and nonsprayed plots shortly after the second harvest is illustrated in Fig. 4.

The control of early blight, late blight, and anthracnose with an

FIG. 4.—FIELD CONTROL OF EARLY BLIGHT.

Plant in upper photo from nonsprayed plot; that in lower photo from plot sprayed with alternate schedule of Fermate-Fermate-bordeaux-Fermate-bordeaux. Condition of vines shortly after second harvest and before killing frost prevented third harvest.

alternate schedule of Fermate-bordeaux was further demonstrated in a factorial experiment carried out in cooperation with the Division of Vegetable Crops of this Station and designed to determine the effect of spraying tomatoes grown at two different fertilizer levels (Table 11). The disease data, taken at the time of the last harvest, indicate fair to good control of defoliation resulting from both early and late blights, and excellent control of late blight fruit rot and anthracnose. The high fertilizer level with no spray resulted in a significant increase in late blight fruit rot, which is attributable to a denser growth of foliage and consequently a more favorable environment for the fruit rot phase of this disease. In terms of yield of ungraded fruit, the fertilizer level exerted a greater influence than the application of sprays. The comparison, however, is not a fair one, since the quality of the fruit, and, therefore, the value of the crop, from the nonsprayed plots was inferior to that from the sprayed plots, regardless of fertilizer level. For example, the average percentages of No. 1 fruit from the first peak harvest, the only harvest graded, at the low fertilizer level were sprayed, 82 and nonsprayed, 68; at the high fertilizer level, sprayed, 73, and nonsprayed, 49.

Table 11.—The Effect of a Spray Schedule on the Disease Control and Yield of John Baer Tomatoes Grown at Two Different Fertility Levels, Lincoln, 1945.

Fertilizer application	Defoliation, per cent*		Late blight, fruit rot, per cent*		Anthracnose,* per cent		Ungraded yield, tons per acre	
	Spray	No spray	Spray	No spray	Spray	No spray	Spray	No spray
300 lbs. 5–20–10.....	51	99	0	16.3	0.5	5.0	12.7	10.1
1,000 lbs. 5–20–20+ 250 lbs. ammonium sulfate side-dressing.....	55	96	0	21.3	0.3	6.8	15.6	13.9
Least difference required for significance (19:1).....	22.3		4.5		4.3		2.5	

*Data taken on the last of three harvests; defoliation resulted from both early and late blight. Fermate-bordeaux-bordeaux-Fermate-bordeaux applied July 7, July 21, Aug. 1, Aug. 8, and Aug. 22, respectively. Harvest dates Aug. 13 and Sept. 5 and 14.

Summary of 1945 results.—The field tests conducted during the 1945 seasons showed no differences among the various fixed coppers against early blight. At least two of them, COCS and Tennessee Tri-

basic, were quite effective against leaf mold. Zerlate, a new material, was just as effective against early blight and leaf mold as the fixed coppers, and more effective against an unknown defoliating disease. It also controlled anthracnose as well as Fermate and was superior in the control of early blight and leaf mold. Its action against late blight was not demonstrated. The alternate schedules of Fermate-fixed coppers or Fermate-bordeaux, in general, gave effective control of early blight, anthracnose, and leaf mold and showed promise against late blight under the conditions encountered during the season. Zerlate, however, appeared to be a better material than Fermate in such schedules because of its better performance against early blight. Bordeaux in alternate schedules with Fermate or Zerlate performed better than the fixed coppers, but this was probably due to the different position of the coppers in the schedule and must be compared in the same arrangement of materials before any conclusions can be drawn. Yield trends indicate that with equivalent disease control, straight copper schedules, wherein the copper is used in the early applications, are detrimental to yield when compared with the alternate schedules.

1946 EXPERIMENTS

Aside from the testing of various organic and inorganic fungicides in one experiment at Geneva, most of the experiments conducted during the 1946 season were designed to compare straight schedules of Zerlate to alternating schedules of Zerlate with various fixed coppers and Bordeaux, wherein the copper fungicides occupied the same position in all schedules. Late blight was the predominant disease in all but one of these experiments; therefore, most of the data recorded in this season are concerned with its control.

A comparison of 15 treatments, involving 12 different fungicides, against early blight and late blight was obtained at Geneva (Table 12). It was impossible to collect early blight data as defoliation or percentage of foliage infection, because of the complicating influence of late blight. Early blight lesions on the stem, however, are clearly distinguishable from late blight lesions, and the disease, therefore, is expressed as percentages of the stem length showing such lesions. It had been observed previously that visible early blight stem lesions rarely extend beyond the defoliated portion of the stem, so that for all practical purposes such data are comparable to defoliation. None of the fixed coppers exhibited any significant differential action against early blight, except Copper Hydrate No. 3, which was inferior. None was

TABLE 12.—EFFECT OF VARIOUS FUNGICIDES ON LATE BLIGHT, EARLY BLIGHT, AND YIELD OF THE JOHN BAER TOMATO, GENEVA, 1946.

MATERIAL*	CONCENTRATION, LBS PER 100 GALS.	LATE BLIGHT FRUIT ROT, PER CENT	EARLY BLIGHT STEM INFECTION, PER CENT	YIELD, TONS PER ACRE, No. 1 EQUIV.†
None	—	49.5	94	6.6
COCS (53%)	4.0	0.5	17	20.1
Copper hydrate No. 3	3.5	1.2	25	16.9
Copper compound A	4.0	1.3	14	16.5
Tenn. Tribasic	4.0	0.3	13	19.0
Microgel	4.0	0.5	13	19.9
Bordeaux	8.0+4.0	0.3	6	16.5
Z–Z–B–Z–B‡	2–8+4	1.2	7	20.3
Zerlate	2.0	15.9	14	16.6
Zerlate+Omilite	2.0+1 pt.	11.2	9	16.4
Fermate	2.0	9.3	48	15.4
Phygon	1.0	0.8	17	18.0
Phygon	2.0	0.4	9	15.3
He 178e	2.0	0.5	9	19.6
Dithane (D-14)+$ZnSO_4$+lime	2 qts.+ 1.0+0.5	2.0	11	19.7
Q-15+Omilite	1 pt.+1 pt.	41.0	90	9.1
Least difference required for significance (19:1)		7.0	6	2.9

*Dates of application: July 12 and 20; Aug. 3, 10, and 21.
†Dates of harvest: Aug. 20 and 29; Sept. 7 and 19; Oct. 4.
‡Alternate schedule of Zerlate and bordeaux.

as effective as bordeaux. Zerlate gave control identical to the fixed coppers; the same material plus Omilite, an adhesive, was slightly better. The alternate schedule of Zerlate-bordeaux was just as effective as bordeaux alone. Phygon (presumably the same compound previously referred to as U. S. R. No. 604) at 1 pound per 100 gallons resulted in a control comparable to the fixed coppers, but at 2 pounds was significantly better. Dithane D–14 and He 178e were slightly better than the fixed coppers but not significantly so. The fruit discoloration observed in previous years on U. S. R. No. 604-sprayed plants was present in the Phygon plots, being less pronounced at the lower concentration, but, nevertheless, present in sufficient amounts to present an unsightly appearance. Fermate was definitely inferior to all treatments except the Q–15 plus Omilite which was not much better than no spray. No attempt was made to differentiate between early and late blight foliage infection.

Late blight data were obtained as the percentage by weight of infected fruit. With 49.5 per cent of the fruit infected in the nonsprayed

plots, the amount in plots sprayed with bordeaux, Zerlate-bordeaux alternate schedule, the fixed coppers, Phygon at two concentrations, He 178e, and Dithane D–14 ranged from 0.3 to 2.0 per cent, no significant difference occurring within this range. Zerlate and Fermate alone were significantly inferior to the above, but Fermate was better than Zerlate. The use of Omilite with Zerlate decreased fruit infection slightly. Q–15 plus Omilite was decidedly inferior. The lower yields from plots sprayed with bordeaux, Phygon at the higher concentration, and Copper Compound A in comparison with those from the other treatments with equivalent disease control are indicative of greater phytotoxicity. The low yields from the Zerlate, Fermate, and Q–15 plots are attributed to poorer disease control. As observed in some of the 1945 experiments, with equivalent disease control, the yield from the Zerlate-bordeaux plots was not exceeded by any other treatment.

The relative performance of Zerlate alone and in various alternate schedules of Zerlate with fixed coppers and Bordeaux against late blight was vividly demonstrated in experiments located at Auburn, Geneva, and Pittsford. Late blight was by far the most important disease in all three experiments and accounted for virtually all of the decrease in yield; therefore, yield served as the best criterion of disease control. It is evident from the data set forth in Table 13 that Zerlate is not as effective against late blight as any one of the various alternate schedules consisting of two copper and three Zerlate sprays. It did, however, produce a significantly greater yield than no spray. The Zerlate-bordeaux schedule at Auburn and Pittsford was better than the same schedule with a fixed copper in place of the bordeaux. Altho the differences were not significant, nevertheless the superior performance of the Zerlate-bordeaux schedule against late blight is analogous to its performance against other diseases reported in previous years' experiments. Data on the percentage of fruit infection in the Geneva experiment also are given, and it is interesting to note that the control obtained with Zerlate alone in this experiment does not hold the same relationship to no spray as it did in the experiment set forth in Table 12. In one experiment it gave 62 per cent control and in the other only 20 per cent; whereas, the alternate schedules gave 97 and 88 per cent control, respectively. The only reason given for this is that the retentiveness or stability of this compound is not great enough against this disease under conditions of high inoculum potential or ideal environment. Support for this view is given in another experiment reported elsewhere (6).

TABLE 13.—INFLUENCE OF VARIOUS SPRAY SCHEDULES ON THE CONTROL OF LATE BLIGHT ON THE JOHN BAER TOMATO AS DETERMINED BY YIELD AT AUBURN, PITTSFORD, AND GENEVA, 1946.

SCHEDULE*	YIELD, TONS PER ACRE†			GENEVA, LATE BLIGHT FRUIT ROT, PER CENT
	Auburn, ungraded	Pittsford, No. 1 equiv.	Geneva, No. 1 equiv.	
O–O–O–O–O	2.6	2.2	3.5	66
Z–Z–Z–Z–Z	7.6	6.6	8.5	53
Z–Z–C–Z–C	—	10.6	—	—
Z–Z–T–Z–T	11.7	—	—	—
Z–Z–M–Z–M	11.6	—	—	—
Z–Z–B–Z–B	13.0	11.5	—	—
Z–T–Z–T–Z	—	—	19.7	7
F–T–F–T–F	—	—	19.3	9
Least difference required for significance (19:1)	1.5	1.4	3.4	5

*Dates of application: At Auburn, July 10 and 19, Aug. 3, 20, and 30; At Pittsford, July 13 and 24, Aug. 6, 19, and 27; At Geneva July 15, 22, and 30 and Aug. 9 and 19. O = No spray; Z = Zerlate and F = Fermate at 2 pounds per 100 gallons; T = Tennessee Tribasic at 4 pounds per 100 gallons, M = Microgel at 4 pounds per 100 gallons, C = Copper Hydrate No. 3 at 4 pounds per 100 gallons; B = Bordeaux 8–4–100.

†Dates of harvest: At Auburn, Aug. 29, Sept. 13 and 19, and Oct. 3; At Pittsford, Aug. 26, Sept. 9 and 23, and Oct. 7; At Geneva, Aug. 22 and 28, Sept. 3, 12, and 27, and Oct. 5.

Altho applications of Zerlate thruout the season were not very effective against late blight, evidence was obtained to indicate that the material will retard the initial buildup of the disease long enough to enable the coppers or other suitable compounds to give adequate protection against further development. An experiment, originally designed to determine the influence of one, two, and three applications of Zerlate against anthracnose and early blight when applied at the time of the first three applications of a normal five-application schedule was threatened with late blight about the middle of August. In order to save the experiment, applications of bordeaux were made to all plots on August 16 and 23. Early blight and anthracnose were negligible, but late blight was quite severe on the plots not having received any sprays prior to the bordeaux (Table 14). Using yield as a criterion of late blight control, highly significant differences in control were obtained with increasing numbers of Zerlate applications. Even one application of Zerlate made a month before the first bordeaux application significantly reduced the late blight and increased the yield, altho the differences were greater with two and three applications.

The effectiveness of delayed applications of copper for the control

TABLE 14.—THE PROTECTIVE VALUE OF ZERLATE AGAINST LATE BLIGHT DETERMINED BY THE YIELD PER ACRE OF UNGRADED FRUIT, GENEVA, 1946.

SCHEDULE*	TONS PER ACRE†
O–O–O–B–B	7.6
Z–O–O–B–B	10.9
Z–Z–O–B–B	16.7
Z–Z–Z–B–B	23.0
Least difference required for significance (99:1)	2.7

*Dates of application: July 16 and 24; Aug. 5, 16, and 23. O = No spray; B = Bordeaux 8–4–100; Z = Zerlate at 2 pounds per 100 gallons.
†Dates of harvest: Sept. 10, 18, and 25; Oct. 4.

of late blight was determined in another experiment at Geneva. Two applications of 400 gallons per acre each were made after late blight occurred in severe form on the foliage and fruit. Pure copper sulfate with and without an adhesive was used as a possible eradicant and compared with bordeaux (Table 15). Again using yield as a measure

TABLE 15.—THE EFFECT OF DELAYED APPLICATIONS OF FUNGICIDES ON THE CONTROL OF LATE BLIGHT AS DETERMINED BY YIELD, GENEVA, 1946.

MATERIAL*	CONCENTRATION, LBS. PER 100 GALS.	YIELD, TONS PER ACRE NO. 1 EQUIV.†
No spray	–	1.9
$CuSO_4 \cdot 5H_2O$+Omilite	1.0	3.8
$CuSO_4 \cdot 5H_2O$	1.0	5.4
$CuSO_4 \cdot 5H_2O$+Omilite	2.0	6.4
Bordeaux	8.0+4.0	9.1
Bordeaux+Omilite	8.0+4.0	9.4
Least difference required for significance (19:1)		2.6

*Dates of application: Aug. 6 and 11 at rate of 400 gallons per acre; late blight present in severe form on foliage and fruit at time of first application.
†Dates of harvest: Aug. 28; Sept. 7 and 27; Oct. 5.

of disease control, it is apparent that bordeaux with or without an adhesive was significantly better than the copper sulfate sprays, which, however, were better than no spray. Unfortunately, no direct comparison was made of the delayed applications with the normal five-application schedule of Zerlate-copper. The Geneva experiment reported in Table 13, however, was adjacent to the above experiment in the same field. The alternate schedule of Zerlate-Tennessee Tribasic in this experiment yielded 19.7 tons compared with the 9.4 tons in the best delayed application. On this basis, it can be said that the delayed

applications, while giving good control of late blight, were not as effective as the fixed schedule of five applications. This is further substantiated by data obtained from similar delayed-spray plots, not included among but adjacent to those reported on at Auburn in Table 13. In these plots, two delayed applications of 400 gallons each of bordeaux were no more effective than the straight Zerlate schedule and only about 60 per cent as effective as the alternate schedule of Zerlate-bordeaux.

The only experiment conducted during 1946 in which late blight did not develop was located at Fredonia. Unfortunately, poor weather at planting time and extreme nonuniformity of soil within the field resulted in yield data entirely unreliable. Nevertheless, sufficient anthracnose developed to provide a fair comparison of the schedules outlined in Table 16. All of the treatments significantly reduced anthracnose,

TABLE 16.—EFFECT OF VARIOUS SCHEDULES ON THE CONTROL OF ANTHRACNOSE AND YIELD OF THE JOHN BAER TOMATO, FREDONIA, 1946.

SCHEDULE*	ANTHRACNOSE, PER CENT	YIELD, TONS PER ACRE No. 1 EQUIV.†
O–O–O–O–O	6.4	4.8
Z–Z–O–O–O	2.5	6.3
Z–Z–Z–O–O	0.9	6.3
Z–Z–Z–Z–Z	0.1	6.4
Z–Z–C–Z–C	0.1	5.0
Z–Z–B–Z–B	0.2	6.3
Least difference required for significance (19:1)	2.6	NS

*Dates of application: July 18; Aug. 1, 13, and 27; Sept. 4. 0 = No spray; Z = Zerlate at 2 pounds per 100 gallons; C = COCS (56%) at 4 pounds per 100 gallons; B = Bordeaux 8–4–100.

†Dates of harvest: Sept. 10 and 26; Oct. 8.

but the reduction was greater with the five-application schedule of Zerlate and the two alternate schedules than with either two or three Zerlate sprays applied early. These data indicate, in this experiment at least, that the alternate schedules of three Zerlate and two coppers are just as effective against anthracnose as five straight applications of Zerlate alone.

DISCUSSION

The primary object of this investigation was to determine the most effective fungicide or combination of fungicides against the three major diseases and not merely to test a given number of materials. Consequently, the choice of materials to be tested was based on pre-

vious performance, and some were dropped in order to test more completely the more promising ones. The most effective fungicide or combination of fungicides against the three major tomato diseases could not be determined in any one experiment or in the experiments of any one year. The presence of only one disease, differences in inoculum potential, varied environal conditions, difficulty in obtaining uniform methods of harvesting, and the lack of significant differences among treatments in any given experiment are only a few of the factors which interfere with an accurate evaluation of the various treatments. Because of these variables the data are best interpreted in accordance with the trends exhibited.

As indicated more completely in the summary, no single fungicide adequately tested under the conditions of this investigation effectively controlled all of the tomato diseases. Of those tested, bordeaux 8–4–100 was never exceeded in the control of early and late blights and often was superior to the other materials, especially the fixed coppers, which is in agreement with the results of other investigators (1, 3, 4, 7). Its specific action against leaf mold was not determined and on the basis of one test was inferior to the fixed coppers for anthracnose control, contrary to the results obtained by McNew (5). Bordeaux, however, when applied early as in a straight five-application schedule appeared to have a detrimental effect on yield. Zerlate gave the best control of anthracnose and leaf mold, was equally as effective against early blight as the fixed coppers, and was not injurious, but it gave only limited control of late blight.

A combination of Zerlate and bordeaux in an alternate schedule might reasonably be expected to give better control of the above four diseases since the two fungicides involved have been shown to give maximal control of the diseases for which they are specific. The proof of this statement lies in the fact that the Zerlate-bordeaux schedule used in these tests was as effective, if not more so, in the control of any one of the four diseases encountered as any single fungicide or other combination of fungicides. Furthermore, yields from plots sprayed according to this schedule were as high, if not higher, than those from plots sprayed with any other schedule, indicating no apparent phytotoxicity.

This apparent lack of plant injury resulting from the use of this schedule can be explained, in part at least, by the position of the bordeaux in the schedule. In the opinion of the writer, the injury from bordeaux, and some of the fixed coppers, was due largely to defloration

described by Horsfall, *et al.* (2), since early harvests were noticeably smaller and no other type of injury was apparent. In the Zerlate-bordeaux schedule the copper fungicide is not used until the third application, which in New York usually does not come until the first week of August or later. Blossoms set after this period rarely produce fruit that reach marketable size except during an exceptionally long harvest season, so that any defloration occurring after this period would hardly be reflected in yield. It is conceivable that some defloration at this time might be advantageous, since it might aid in the production of larger fruit.

The use of a five-application schedule of Zerlate-bordeaux, wherein Zerlate is applied in the first, second, and fourth applications and bordeaux in the third and fifth, is practical, at least in regions with seasons comparable to those of western New York. The relatively noninjurious Zerlate applied in the early sprays when the plant is most susceptible to spray injury affords protection against early blight, leaf mold, and anthracnose. It also holds late blight in check until the more tenacious and effective bordeaux is applied. Whether or not the newer and as yet inadequately tested materials, such as Dithane D–14, the zinc ethylene bisdithiocarbamates, or any other fungicide, will replace the alternate schedule entirely or in part remains to be determined, but they will have to be as effective as Zerlate-bordeaux in a five-application schedule or sufficiently more effective with a larger number of applications to offset the additional cost.

SUMMARY

Experiments were conducted during 1944 to 1946, inclusive, in various tomato-growing areas in western New York to determine which fungicide or combination of fungicides would give the most effective control with the least amount of plant injury of all five major tomato diseases prevalent in that area. Data were obtained on four diseases, namely, early blight, late blight, anthracnose, and leaf mold. Septoria blight was not encountered in sufficient amount to evaluate any fungicide accurately.

A number of available fungicides were tested each year in anticipation of finding one that would be most effective, at least against the major diseases, early blight, late blight, and anthracnose. In addition, various alternate schedules of Fermate or Zerlate and the copper fungicides were investigated.

No single fungicide, adequately tested, gave maximal control of the four diseases encountered. The copper fungicides, COCS, Compound A, Microgel, Tennessee Tribasic, and bordeaux, gave effective control of early and late blights. Bordeaux was superior to the fixed coppers but more injurious when used in a straight five-application schedule, altho in one experiment Compound A was just as injurious. COCS and Tennessee Tribasic gave good control of leaf mold. All were inadequate for the control of anthracnose. Yield trends indicated that with equivalent disease control the copper fungicides were detrimental to yield, some more than others, when used in early applications.

Phygon was effective against early blight, late blight, and anthracnose, but produced objectionable fruit discoloration and indications in one test pointed to a phytotoxicity comparable to that of the coppers when used at the higher concentraion.

Dithane D–14 and He 178e gave good control of early and late blights and did not appear injurious, but were not adequately tested against leaf mold and anthracnose.

Fermate was effective against anthracnose and leaf mold but not against early and late blights. Zerlate, equal to Fermate for anthracnose and superior to the latter because of better control of early blight and leaf mold, gave only limited control of late blight. This material, however, did hold late blight in check long enough to enable the copper fungicides to check the disease more completely.

Satisfactory control of the three major diseases, early blight, late blight, and anthracnose, was obtained only when Fermate or Zerlate was used in various alternate schedules with copper fungicides. These schedules also controlled leaf mold. Delayed applications of copper fungicides were not nearly as effective against late blight as the regular alternate schedules. Trends in disease control and yield indicated that the Zerlate-bordeaux schedule in the order of application of Zerlate-Zerlate-bordeaux-Zerlate-bordeaux, using bordeaux 8–4–100 and Zerlate 2 pounds to 100 gallons, was superior to any other combination tested, altho some of the fixed coppers performed nearly as well when used in place of the bordeaux in such a schedule. A number of experiments indicated that applications of copper made earlier than the third spray might have a detrimental effect on yield.

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